Use of agricultural fields by birds during canola planting in Saskatchewan: potential for exposure to pesticides

Pamela A. Martin, Todd W. Arnold and Douglas J. Forsyth

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USE OF AGRICULTURAL FIELDS BY BIRDS DURING CANOLA PLANTING IN SASKATCHEWAN: POTENTIAL FOR EXPOSURE TO PESTICIDES

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ABSTRACT

We determined bird use of agricultural fields during the spring canola planting season in central Saskatchewan to assess the potential for birds to be exposed to granular insecticides and seed-coatings. We censused 365 fields using roadside point counts and 60 fields using 1-km line transects, between 17 and 30 May, 1992. Almost 60 avian species were observed. Totals of 48 and 45 species were encountered in roadside point counts and line transect counts, respectively. Horned Larks (*Eremophila alpestris*) and Savannah Sparrows (*Passerculus sandwichensis*) were the species most frequently observed. However, Lapland Longspurs (*Calcarius lapponicus*) were seen sporadically in large numbers and were present in 43% of fields censused by line transects. Of resident breeding birds, Horned Larks (subspecies *enthymia*) occurred at the highest densities (14.3 birds per 100 ha). However, flocks of arctic-nesting songbirds, primarily Lapland Longspurs and Horned Larks (subspecies *hoyti*), occurred at a mean density of 782 birds per 100 ha. Migrating shorebirds, including Lesser Golden and Black-bellied Plovers (*Pluvialis dominica* and *P. squatarola*) and *Calidris* species, were present at 28.7 birds per 100 ha. The presence of large numbers of ground-feeding migrant species in cultivated fields in the spring, suggests that applications of granular insecticides or insecticidal seed-treatments may pose a substantial risk for wildlife.

RÉSUMÉ

Nous avons déterminé l'utilisation des champs agricoles par les oiseaux durant l'ensemencement printanier du canola dans le centre de la Saskatchewan pour évaluer le risque d'exposition des oiseaux aux insecticides granulaires et aux enrobages des semences. Nous avons effectué des dénombrements ponctuels le long des routes pour 365 champs et des dénombrements par transects linéaires de 1 km pour 60 champs, du 17 au 30 mai 1992. Nous avons observé 48 espèces lors des dénombrements ponctuels le long des routes et 45 espèces lors des dénombrements par transects linéaires. L'Alouette hausse-col (*Eremophila alpestris*) et le Bruant des prés (*Passerculus sandwichensis*) ont été les espèces les plus fréquemment observées. Cependant, le Bruant lapon (*Calcarius lapponicus*) a été vu sporadiquement en grand nombre et il a été observé dans 43% des champs où ont été effectués les relevés par transects linéaires. Parmi les oiseaux nicheurs résidents, c'est l'Alouette hausse-col de la sous-espèce *enthymia* qui a présenté les plus fortes densités (14,3 oiseaux par 100 ha). Par ailleurs, la densité moyenne des bandes d'oiseaux chanteurs nichant dans l'Arctique, principalement de Bruants lapons et d'Alouettes hausse-col de la sous-espèce *hoyti*, s'élevait à 782 oiseaux par 100 ha. Enfin, la densité moyenne des groupes d'oiseaux de rivage migrateurs, incluant le Pluvier bronzé (*Pluvialis dominica*), le Pluvier argenté (*P. squatarola*) et des espèces du genre *Calidris*, était de 28,7 oiseaux par 100 hectare. La présence d'effectifs considérables d'oiseaux migrateurs s'alimentant au sol dans les champs cultivés au printemps laisse penser que les applications d'insecticides granulaires ou les traitements insecticides des semences peuvent présenter un risque important pour la faune.

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INTRODUCTION

Canola is an increasingly important crop in prairie Canada, providing an economically viable alternative to the more traditional cereal grain crops. It was developed from rapeseed by plant breeders at Agriculture Canada (Saskatoon) and the University of Manitoba who succeeded in producing cultivars with low erucic acid and low glucosinolate content (Stefansson and Downey 1995). The total area planted to canola annually throughout Canada increased from 2.6 million hectares in 1986 to 4.9 million hectares in 2004; about 80% of annual production occurred in Alberta and Saskatchewan (Canola Council of Canada website). Canola is predominantly grown in the Parkland ecoregion of the Prairie Provinces. Flea beetles are a ubiquitous pest in canola, although they occur with increased regularity at high densities in certain areas. To control the damage caused to the susceptible seedling plants, an estimated 95% of farmers routinely plant canola seed treated prophylactically with an insecticide, a fungicide or a combination of the two (Canola Council of Canada 2000).

Lindane was used for this purpose at least as early as 1971, coinciding with the conversion of Canada's rapeseed cropland to canola (Stefansson and Downey 1995). Usage increased approximately fourfold between 1975 and 2000 as canola gained in popularity as a crop (Li et al. 2004). Registrations for lindane-based canola seed treatment were cancelled in 2002 (Pest Management Regulatory Agency 2002), but the cancellation was challenged by the manufacturer. The Lindane Board of Review held public hearings in January 2005; as of July 2005, a report with recommendations to be considered by the Minister of Health was in preparation. Insecticidal seed treatments currently registered for flea beetle control in canola (Saskatchewan Agriculture, Food and Rural Revitalization 2005) include Gaucho (imidacloprid + two fungicides), Poncho (clothianidin) and Helix (thiamethoxam + three fungicides). In the Parkland regions of Manitoba and Saskatchewan, where damage from flea beetles is consistently high, the application of granular insecticide formulations in combination with seed treatment has been recommended (Thomas 2003). The granular products, Furadan CR-10, 5G and 10G (carbofuran) and Counter 5G and 15G (terbufos), have been mixed with canola seed at the time of planting; however, none of these products remain on the market in Canada.

Granular insecticides applied with the seed are known to be hazardous to birds. In

particular, cases of avian mortality resulting from field applications of granular Furadan have been documented. Most common among these are waterfowl die-offs in flooded rice or turnip fields, with some incidents involving up to several hundred birds (Mineau 1993). Waterfowl carcasses are large and conspicuous, which undoubtedly increases the likelihood that this type of incident will be reported by the general public (Mineau 1988). In contrast, passerine bird carcasses are small and inconspicuous and most probably disappear before they are noticed (Balcomb 1986). Nevertheless, some cases of passerine mortality following applications of granular Furadan have been documented (Mineau 1993). The first incident was in Saskatchewan during the last week of May 1984. An estimated 2000 Lapland Longspurs (*Calcarius lapponicus*) were killed in canola fields after a broadcast application of Furadan CR-10, followed by harrowing for incorporation into the soil. The second incident involved an estimated 500 to 1000 Savannah Sparrows (*Passerculus sandwichensis*) in turnip fields in British Columbia during September 1986. A special review of the hazard posed by granular Furadan to birds, initiated in the United States in 1985, resulted in cancellation of registrations for use on most crops, including canola. Restricted use is currently registered for spinach grown for seed and curcubits (U.S. Environmental Protection Agency 2004). In Canada, the registrations for the use of 10% granular Furadan on canola were cancelled between 1995 and 1997 (Pest Management Regulatory Agency 1995). Registration of the 5% corncob formulation was cancelled in 1998 (Bayer CropScience Canada website).

The review of Furadan products that was conducted in Canada (Agriculture Canada 1993) included an evaluation by the Canadian Wildlife Service of the risks posed by this insecticide. Mineau (1993) identified the particular hazard of the use of the granular formulation applied with canola seed to songbirds, especially arctic migrants such as the Lapland Longspur. Granular treatments in canola present a particular risk to these birds because almost all canola planting takes place during the latter half of May and early June, coinciding closely with the northward migration of large numbers of arctic-nesting songbirds, shorebirds, and geese. Maze et al. (1991) addressed the question of availability of granules on the soil surface. They calculated that between 0.1% and 7% of the total granules applied may remain on the soil surface, depending on the planting implement used and the soil condition at planting, resulting in mean counts between 3,150 and 172,950 exposed granules per ha. The propensity of small

passerines to ingest Furadan CR-10 corn-cob based granule has been documented by the above-mentioned longspur incident and a case in Ontario where approximately 200-300 sparrows and blackbirds of unidentified species were killed in a field where canola seed mixed with granules had been broadcast onto the soil surface and then harrowed (Mineau 1993). These birds were presumably selecting the exposed granules, probably mistaken either for grit or food, from the soil surface.

There are many published observations of huge flocks of Lapland Longspurs, sometimes totalling tens of thousands of birds, moving through farmland (Houston 1971, 1972; Gollop 1986, 1987) and foraging in agricultural fields (Houston and Street 1959, Roy 1996). No effort has been made to quantify bird use of cropland to date, however. In addition to the arctic migrants, early-nesting resident species are also defending territories in agricultural areas by this time. The objective of this study was to systematically assess species diversity and density of both migrant and resident birds in fields during the peak of canola planting in an important canola-growing region in central Saskatchewan. Although granular insecticides are no longer registered for use on canola in North America, this information is needed to assess the potential exposure of birds to pesticides applied with canola seed in the past, present and future. Other crops such as cereals, flax, pulse and sunflowers are also seeded during the month of May (Manitoba Agriculture and Food 2002), overlapping with the spring migration of birds. Therefore, the data generated by this study will be useful to evaluate potential exposure of birds to a variety of seed types treated with fungicides, insecticides or both.

STUDY AREA AND METHODS

Our study was conducted within a 20-km radius of the town of Blaine Lake (52° 50' latitude, 106° 54' longitude), approximately 72 km north of Saskatoon, Saskatchewan. This area, which is situated in the Aspen Parkland ecoregion of the Prairie ecozone, has numerous aspen bluffs and many semi-permanent and permanent wetlands and lakes, including Redberry, Blaine, and Paddling Lakes. The topography is gently rolling and soil is classified as dark brown. Canola is a popular crop in the area; in 2003 it accounted for 28% of all crops grown (Saskatchewan Agriculture, Food and Rural Revitalization 2004). Bird use of fields was

determined in two ways: extensive roadside surveys throughout the area, and intensive inner-field line transects in a smaller sample of fields. All surveys were conducted between 17 and 30 May, 1992, during the typical spring planting season in that area. Surveys were conducted only on secondary roads, generally by two observers simultaneously in fields on either side of the road.

Roadside point count surveys

Roadside surveys were conducted between 0600 and 1100 h or between 1800 and 2000 h. A vehicle carrying two observers stopped every 0.8 km; both observers got out of the vehicle and positioned themselves facing into the edge of the field adjacent to them, on either the right or left side of the road. Soil surface conditions of each censused field were recorded. Categories included 1) black cultivated or seeded; 2) stubble mulch - cultivated and possibly seeded, but with a layer of broken-up crop residue on the surface; 3) grain stubble - standing cereal crop stubble, uncultivated since previous harvest; 4) canola stubble - standing canola stubble, uncultivated since the previous harvest; and 5) growing grain - germinated fall-planted wheat or rye, typically in soil that was either heavily cultivated or had a light stubble mulch.

Survey methods were similar to those tested by Freemark and Rogers (1995) which are based on those used by the Breeding Bird Survey of North America (Robbins et al. 1986), but modified for use in surveying cropland. Point counts (3 min duration) were conducted from the road-field interface. Birds seen or heard within a 400-m radius semicircle within the censused field were recorded (Figure 1); birds observed only in fencerows, roadside ditches, or non-crop areas within fields were not counted. Surveys were conducted within the constraints of low wind conditions (<15km/h) and no significant precipitation. Temperature, cloud cover, precipitation and wind were recorded at the beginning and end of each survey.

Line transect surveys

Field-interior line transect surveys were conducted between 0600 and 1400 h. Variable-width line transects were run through a total of 60 fields. We only censused fields that were either ready for immediate planting or had recently been planted and were therefore fairly heavily cultivated. We assumed that birds found in this sample of fields would be indicative of

those found on freshly planted canola fields. Transects began at least 50 m from the field edges. They were U-shaped, consisting of two parallel 400-m segments running perpendicular to the road into the centre of the field, joined by a 200-m segment running parallel to the road (Figure 1). Distances were measured using pedometers, and transects were 1 km (±20 m) in length. We recorded the species, number, and location of all birds seen or heard within the censused field. Locations were recorded as the distance of the initial detection perpendicular from the transect line, as required for density determination. As well, distance of each detection along the transect and the side and segment of the transect on which it occurred were noted to ascertain that no birds were counted twice. Birds that flew over the field at a height of >30 m were not counted; those that were foraging over the field at a height of <30 m were included. Bird density was determined using the Fourier and exponential power series estimators provided in the TRANSECT computer program (Burnham et al. 1980). Density was estimated by counting individual resident breeding birds (typically singing males) as the detection unit, whereas flocks were the unit of detection for arctic migrants and blackbirds. The density of flocks, as calculated using the TRANSECT program, was multiplied by the mean flock size to obtain overall density of flocking species.

Thirty-four of the 60 fields censused by line transects were also censused using the point count method immediately before running the transect, and differences in detectability among species were compared between the two census methods using a 2-way contingency table (G-tests). We used the SAS program (SAS Institute Inc 1985) for all statistical analyses. We used one-way analyses of variance to test for differences in the abundance of the most commonly detected species among the five field condition types, using the roadside point count data. Means were separated using Tukey's honestly significant difference (HSD) tests.

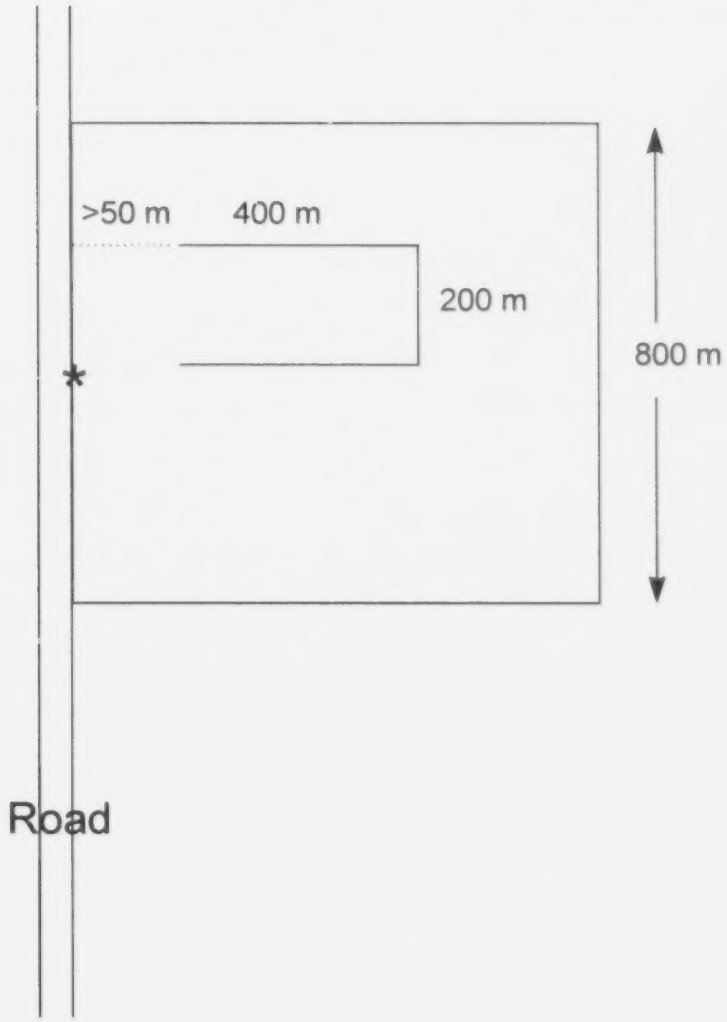

Figure 1. Layout of survey field showing interior line transect and roadside point count locations (*).

RESULTS

Comparison of the two census methods

A total of 48 species was observed during roadside point counts conducted at the edges of 365 fields (Table 1). Horned Larks (*Eremophila alpestris*) and Savannah Sparrows were the most commonly observed, and were detected in 38 and 32% of all censused fields, respectively. Although large numbers of Ring-billed Gulls (*Larus delawarensis*) and Lapland Longspurs were counted, they generally occurred in large flocks and were detected in only 8.7 and 3.0% of the fields, respectively (Table 1).

Forty-five species were identified in line transect counts of 60 fields. Once again, Horned Larks and Savannah Sparrows were the most commonly detected and were seen in 82 and 47% of all fields, respectively (Table 1). In contrast to the roadside results, Lapland Longspurs were detected in 43% of all line-transect fields with a total of almost 3,000 birds being observed (Table 1). For fields on which both types of surveys had been conducted, proportions of total detections of Horned Larks, Savannah Sparrows, Lapland Longspurs and all other species combined, were compared between the two survey types using a two-way contingency table. The overall test was highly significant ($G = 256.5$, $P < 0.0001$). The most obvious bias occurred in the detectability of Lapland Longspurs, which accounted for only 24% of total birds detected by the point count versus 64.2% detected using the line transect method.

Field type preferences

A few of the species commonly observed during roadside point counts exhibited preferences for different field types. Savannah Sparrows occurred in greater numbers in fields with standing canola stubble and stubble mulch and in lower numbers in black fields (Table 2). More Red-winged Blackbirds (*Agelaius phoeniceus*) and Killdeers (*Charadrius vociferus*) were encountered in fields of growing grain, while Brewer's Blackbirds (*Euphagus cyanocephalus*) appeared to prefer fields of canola stubble (Table 2). Highest numbers of Clay-colored Sparrows (*Spizella pallida*) were observed in fields of grain stubble, whereas fields of stubble mulch were least preferred (Table 2). Other species were not observed in adequate numbers to show statistically significant preferences among the different field surface conditions.

TABLE 1. Number and percent of fields censused in which birds were detected, and total number of individuals per species observed during roadside point counts and line transect surveys conducted in fields during the canola planting season in central Saskatchewan.

Species	Scientific name	Status[a]	Food type[b]	Foraging Location[c]	Point Counts (n = 365)			Line Transects (n = 60)		
					No. Fields	(%)	Total birds	No. Fields	(%)	Total birds
Greater White-fronted Goose	*Anser albifrons*	M	G, I	W	2	0.5	26	0	0.0	0
Canada Goose	*Branta canadensis*	R	G, I	W	4	1.1	11	2	3.3	5
Mallard	*Anas platyrhynchos*	R	I, S	W	9	2.5	16	2	3.3	4
Northern Pintail	*Anas acuta*	R	I, S	W	3	0.8	6	0	0.0	0
American Wigeon	*Anas americana*	R	I, S	W	1	0.3	2	1	1.7	2
Gadwall	*Anas strepera*	R	I, S	W	1	0.3	2	2	3.3	4
Northern Shoveler	*Anas clypeata*	R	I, S	W	1	0.3	2	2	3.3	4
American Avocet	*Recurvirostra americana*	R	O	W	0	0.0	0	1	1.7	1
Killdeer	*Charadrius vociferus*	R	I	G	16	4.4	24	5	8.3	5
Black-bellied Plover	*Pluvialis squatarola*	M	I	G	1	0.3	30	1	1.7	24
Lesser Golden Plover	*Pluvialis dominica*	M	I	G	6	1.6	79	3	5.0	33
Willet	*Catoptrophorus semipalmatus*	R	I	G	1	0.3	1	3	5.0	3
Buff-breasted Sandpiper	*Tryngites subruficollis*	M	I	G	1	0.3	3	4	6.7	22
Semi-palmated Sandpiper	*Calidris pusilla*	M	I	G	1	0.3	2	0	0.0	0
"Peep"	*Calidris sp.*	M	I	G	4	1.1	118	4	6.7	49
unknown shorebird			I	G	1	0.3	2	2	3.3	31
Ring-billed Gull	*Larus delawarensis*	R	O	G	32	8.8	170	15	25.0	119
California Gull	*Larus californicus*	I	O	LD	1	0.3	1	0	0.0	0
Franklin's Gull	*Larus pipixcan*	R	I	G	2	0.5	2	3	5.0	43
Turkey Vulture	*Cathartes aura*	R	C	HP	1	0.3	2	0	0.0	0
Northern Harrier	*Circus cyaneus*	R	M	LP	5	1.4	5	5	8.3	5
Swainson's Hawk	*Buteo swainsoni*	R	M	HP	5	1.4	5	2	3.3	2
Red-tailed Hawk	*Buteo jamaicensis*	R	M	HP	4	1.1	4	0	0.0	0
Merlin	*Falco columbarius*	R	B	A	1	0.3	1	0	0.0	0
Peregrine Falcon	*Falco peregrinus*	M	B	A	1	0.3	1	3	5.0	4
Gray Partridge	*Perdix perdix*	R	S, I	G	1	0.3	2	0	0.0	0

Table 1 continued next page

Table 1 continued

Rock Dove	*Columba livia*	R	S	G	1	0.3	1		0	0.0	0
Eastern Kingbird	*Tyrannus tyrannus*	R	I	A	4	1.1	5		2	3.3	2
Western Kingbird	*Tyrannus verticalis*	R	I	A	1	0.3	2		1	1.7	2
Least Flycatcher	*Empidonax minimus*	R	I	S	5	1.4	7		1	1.7	5
Horned Lark	*Eremophila alpestris*	r, m	O	G	138	37.8	360		49	81.7	511
American Crow	*Corvus brachyrhynchos*	R	O	G	26	7.1	40		14	23.3	24
Common Raven	*Corvus corvax*	R	O	G	0	0.0	0		1	1.7	1
Black-billed Magpie	*Pica pica*	R	O	G	14	3.8	21		2	3.3	2
Swainson's Thrush	*Catharus ustulatus*	M	I	S	11	3.0	20		4	6.7	7
Mountain Bluebird	*Sialia currucoides*	R	I	G	2	0.5	4		0	0.0	0
American Robin	*Turdus migratorius*	R	I	G	10	2.7	15		3	5.0	5
Sprague's Pipit	*Anthus spragueii*	R	I, S	G	0	0.0	0		2	3.3	2
American Pipit	*Anthus rubescens*	M	I, S	G	0	0.0	0		3	5.0	21
European Starling	*Sturnus vulgaris*	R	I, S	G	2	0.5	6		2	3.3	3
Cape May Warbler	*Dendroica tigrina*	M	I	T	1	0.3	1		0	0.0	0
Yellow-rumped Warbler	*Dendroica coronata*	M	I	T	9	2.5	29		0	0.0	0
Blackpoll Warbler	*Dendroica striata*	M	I	T	2	0.5	2		0	0.0	0
Yellow Warbler	*Dendroica petechia*	R	I	S	1	0.3	3		2	3.3	7
American Redstart	*Setophaga ruticilla*	R	I	S	1	0.3	1		0	0.0	0
Savannah Sparrow	*Passerculus sandwichensis*	R	I,S	G	118	32.3	197		28	46.7	74
Vesper Sparrow	*Pooecetes gramineus*	R	I, S	G	66	18.1	92		16	26.7	19
Song Sparrow	*Melospiza melodia*	R	I, S	G	1	0.3	1		1	1.7	1
Clay-colored Sparrow	*Spizella pallida*	R	I, S	G	22	6.0	55		8	13.3	18
unknown sparrow		R	I, S	G	24	6.6	37		7	11.7	14
Lapland Longspur	*Calcarius lapponicus*	M	I, S	G	11	3.0	555		26	43.3	2,958
Smith's Longspur	*Calcarius pictus*	M	I, S	G	0	0.0	0		1	1.7	45
Snow Bunting	*Plectrophenax nivalis*	M	I, S	G	0	0.0	0		1	1.7	30
Western Meadowlark	*Sturnella neglecta*	R	I, S	G	1	0.3	1		0	0.0	0
Red-winged Blackbird	*Agelaius phoeniceus*	R	I, S	G	11	3.0	28		6	10.0	10
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	R	I, S	G	7	1.9	24		3	5.0	8
Brewer's Blackbird	*Euphagus cyanocephalus*	R	I, S	G	8	2.2	58		5	8.3	38
Rusty Blackbird	*Euphagus carolinus*	R	I, S	G	0	0.0	0		1	1.7	1

Table 1 continued next page

Table 1 continued.

Brown-headed Cowbird	*Molothrus ater*	R	I, S	G	9	2.5	23		4	6.7	13
Total Species							**48**				**45**

[a] Status: migrant, resident, incidental.
[b] Food types (primary, secondary): M = mammals; B = birds; I = insects; S = seeds; G = green vegetation; C = carrion; O = omnivorous diet.
[c] Foraging location: W = water; G = ground; A = aerial; LD = low diving; HP = high patrol over ground; LP = low patrol over ground; S = shrubs; T = trees.

Density estimates

Horned Larks were the most numerous resident species in the agricultural fields and they occurred at a density of 14.3 birds per 100 ha (Table 3). Savannah Sparrows, the next most abundant species, were present at a density of 11.6 birds per 100 ha, whereas all other sparrow species combined were present at a density of 13.7 birds per 100 ha (Table 3). Flocks of migrating passerines, of which Lapland Longspurs were by far the most common species, were present in worked fields at extremely high densities (782 birds per 100 ha), whereas arctic migrant shorebirds were present at only 28.7 birds per 100 ha (Table 3).

TABLE 2. Mean (SE) number of several common species detected per point count in fields of differing conditions during the canola planting season in central Saskatchewan.

	Field Condition[c]				
	B (n=162)	SM (n=122)	GS (n=56)	CS (n=8)	GG (n=17)
MEAN ABUNDANCES					
Horned Lark	1.21 (0.36)	1.13 (0.24)	0.27 (0.09)	0.63 (0.32)	0.35 (0.15)
Savannah Sparrow	0.36 (0.05)[a]	0.74 (0.10)[b]	0.63 (0.11)[ab]	1.25 (0.62)[b]	0.24 (0.14)[ab]
Lapland Longspur	2.46 (1.99)	1.23 (1.23)	0	0.75 (0.49)	0
Vesper Sparrow	0.25 (0.05)	0.23 (0.05)	0.36 (0.11)	0.13 (0.13)	0.12 (0.08)
Clay-colored Sparrow	0.12 (0.04)[a]	0.04 (0.02)[b]	0.52 (0.29)[a]	0.13 (0.13)[ab]	0.06 (0.06)[ab]
Killdeer	0.10 (0.03)[ab]	0.02 (0.02)[a]	0[a]	0[a]	0.24 (0.16)[b]
American Crow	0.14 (0.05)	0.10 (0.03)	0.05 (0.03)	0	0.18 (0.13)
Black-billed Magpie	0	0.08 (0.05)	0.07 (0.03)	0	0.06 (0.06)
Ring-billed Gull	0.91 (0.46)	0.08 (0.03)	0.13 (0.09)	0	0.29 (0.14)
Brown-headed Cowbird	0.06 (0.03)	0.09 (0.05)	0	0.25 (0.25)	0
Brewer's Blackbird	0.16 (0.09)[a]	0.01 (0.01)[a]	0.02 (0.02)[a]	3.75 (3.75)[b]	0
Red-winged Blackbird	0.06 (0.02)[a]	0.07 (0.05)[a]	0[a]	0.13 (0.13)[ab]	0.59 (0.59)[b]
American Robin	0.04 (0.02)	0.04 (0.02)	0.04 (0.04)	0.25 (0.25)	0

[ab] Means with differing superscript letters are significantly different ($p < 0.05$: ANOVA and Tukey's HSD test).

[c] B = black earth; SM = stubble mulch; GS = grain stubble; GG = growing grain. See methods for more details.

TABLE 3. Bird abundance associated with worked fields during the canola planting season in central Saskatchewan.

Group	N[a]	Mean (SE) number flocks per 100 ha	Mean (SE) flock size	Mean (SE) birds per 100 ha
Resident Breeders				
Savannah Sparrow	75	-	-	11.6 (1.6)
Horned Lark[b]	138	-	-	14.3 (1.2)
other sparrows[c]	39	-	-	13.7 (3.9)
Resident Flocks				
blackbirds[d]	24	3.7 (1.2)	2.5 (0.4)	9.25 (3.4)
Migrant Flocks				
passerines[e]	103	23.7 (5.2)	33.0 (6.9)	782.1 (239.8)
shorebirds[f]	36	6.1 (1.2)	4.7 (1.0)	28.7 (8.3)

[a] Number of individuals detected in resident breeder groups, number of flocks in flocked groups.
[b] Includes Horned Larks seen individually or in pairs.
[c] Includes Clay-colored, Vesper, Song and unidentified sparrows, and Sprague's Pipits.
[d] Includes Red-winged, Yellow-headed and Brewer's blackbirds, Brown-headed Cowbirds and European Starlings.
[e] Includes Lapland and Smith's longspurs, Snow Buntings, Water Pipits and groups of >2 Horned Larks.
[f] Includes Lesser Golden and Black-bellied plovers, Semipalmated Sandpipers, unidentified *Calidris* species, Buff-breasted Sandpipers, Killdeers, and other unidentified shorebirds.

DISCUSSION

A wide variety of bird species used agricultural fields during the early spring planting season in Saskatchewan. Although there is evidence of preference among certain species for fields of varying soil surface conditions, results are difficult to interpret. Resident species which nest in or beside fields, such as Savannah Sparrows, Horned Larks and Vesper Sparrows (*Pooecetes gramineus*), may have selected territories in fields earlier in the spring prior to cultivation or planting, when the conditions of the soil surface were very different. For example, Savannah Sparrows were seen in significantly greater numbers in fields with stubble mulch. It is possible that these fields contained standing grain stubble when the birds first arrived and were suitable habitat at that time, but were subsequently cultivated. Clay-colored Sparrows, on the other hand, appeared to spend most of their time in the shrubs and tall grass of field margins and only ventured short distances into fields. These sparrows were usually seen in fields in small groups, suggesting that fields were not part of their breeding territories, but were non-territorial foraging areas. Clay-colored Sparrows are known to feed extensively outside of their nesting territories (Knapton 1980). Their apparent preference for grain stubble fields probably reflects their reluctance to forage out into areas with the limited cover typical of heavily worked fields. Although preferences for field types could not be determined statistically for Lapland Longspurs, it is obvious that they were entirely absent from grain stubble or growing grain (Table 2). They were observed in high, though variable, numbers in black fields and stubble mulch fields. Both of these surface types indicate fields which were either freshly planted or were prepared for immediate planting.

Some of the birds most commonly observed on line transect counts in fields potentially ready for seeding were species for which there are documented cases of mortality resulting from the application of Furadan granules. These species include Horned Larks, Lapland Longspurs, Savannah Sparrows, Red-winged and Yellow-headed Blackbirds (*Xanthocephalus xanthocephalus*), and Killdeers (Mineau 1993). Casualties have also been reported (Mineau 1993) for a variety of waterfowl including Canada Geese (*Branta canadensis*), Mallards (*Anas platyrhynchos*), Northern Pintails (*Anas acuta*), Gadwalls (*Anas strepera*) and American Wigeon (*Anas americana*); raptors such as Northern Harriers (*Circus cyaneus*) and Red-tailed Hawks

(*Buteo jamaicensis*); as well as Common Ravens (*Corvus corvax*), American Robins (*Turdus migratorius*), and Brown-headed Cowbirds (*Molothrus ater*). All of these species were seen foraging on fields in our study.

Although there is a broad taxonomic range of species included in these reports of Furadan-related mortalities, most of the birds killed were ground-feeding insectivores or omnivores. Mortality of raptors generally results from secondary poisoning through the consumption of intoxicated or dead birds (Mineau 1993). Many other species with similar foraging habits (Table 1) that were present in the fields during or shortly after application of granules may be equally susceptible to poisoning. Probably at greatest risk are the flocks of arctic-nesting migrants, which occurred at relatively high densities in these fields at seeding time. The occurrence of Killdeer casualties suggests that other field-feeding shorebirds, including Black-bellied Plovers (*Pluvialis squatarola*) and Lesser Golden Plovers (*Pluvialis dominica*), and mixed flocks of *Calidris* sandpipers (peeps) may be susceptible to the hazards presented by granular insecticides in canola fields. Of particular concern are the several sightings of field-feeding Buff-breasted Sandpipers (*Tryngites subruficollis*), a species whose conservation status is uncertain and which appears to be undergoing population declines (Kaufman 1996).

The variety of species observed in canola fields in central Saskatchewan may be influenced by the surrounding habitat of the area (Best and Fischer 1992). The large number of lakes and smaller wetlands would have attracted many waterfowl and shorebirds. The presence of shrubby field margins and patches of aspen bluff provided habitat for many passerine species. Although these features are desirable, they probably increase the overall potential for avian exposure to granular insecticides (Best and Fischer 1992) and treated seed.

Treated canola seed may be ingested by some species of songbird, but little information exists about the attractiveness of canola seed to songbirds. Although rapeseed, the genetic predecessor of canola, is included in some wild bird seed mixtures, a study of birds at feeders found almost no interest in rapeseed by the species of bird being observed (Geis 1980). Nonetheless, domestic canaries (*Serinus canarius*) and other caged species of finches (Fringillidae) consume canola seed (Harper et al. 1998). Some mortality might result if finches

in the wild were to consume canola seed treated with imidacloprid. Cereal seed treated with imidacloprid (Berny et al. 1999) caused the deaths of grey partridge, pigeons and ducks in eight incidents in France (de Snoo et al. 1999). On the other hand, songbirds would likely discard the hulls of treated canola seed, thereby removing much of the insecticide (Avery et al. 1997), whereas the treated cereal seed used in France was probably swallowed whole. The acute oral LD50 values (Tomlin 2003) for Bobwhite Quail (*Colinus virginianus*) of thiamethoxam (1552 mg/kg) and clothianidin (> 2000 mg/kg), the other two currently registered insecticides for treatment of canola seed, are considerably higher than that of imidacloprid (152 mg/kg). Although finches may be more sensitive than quail to these chemicals, the risk of poisoning by the latter two insecticides is evidently less than that of imidacloprid.

These insecticides, in addition to various fungicides (captan, carbathiin, difenoconazole, fludioxonil, iprodione, maneb, mancozeb, metalaxyl, metiram, tebuconazole, thiabendazole, thiamethoxam, thiram, triademenol and triticonazole) are used as seed treatments for cereals, flax, beans, peas, sunflower, millet, and others (Saskatchewan Agriculture, Food and Rural Revitalization 2005). Thus, the data reported herein can be used to assess the exposure of birds to these chemicals on other seeds that are planted during May and early June.

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